Issues in Biodiesel Production and Safety

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Outline

- Background on biodiesel
- Biodiesel production
- Feedstocks
- Safety

The biodiesel reaction

- Produced by a chemical reaction between methanol (or ethanol) and an oil or fat.
- 100 lb Soybean oil + 10 lb methanol

  ➔100 lb biodiesel + 10 lb glycerin
- Requires a catalyst

(such as caustic soda)

Advantages of Biodiesel

- Biodegradable, nontoxic, renewable
- Very favorable energy balance, 3.2 to 1.
- Lower emissions (Example: DDC Series 50)
  - Carbon monoxide: 38% lower
  - Unburned HC: 83% lower
  - Particulates: 52% lower
  - Smoke and odor are much better
  - But, oxides of nitrogen are 12.7% higher

Advantages of Biodiesel

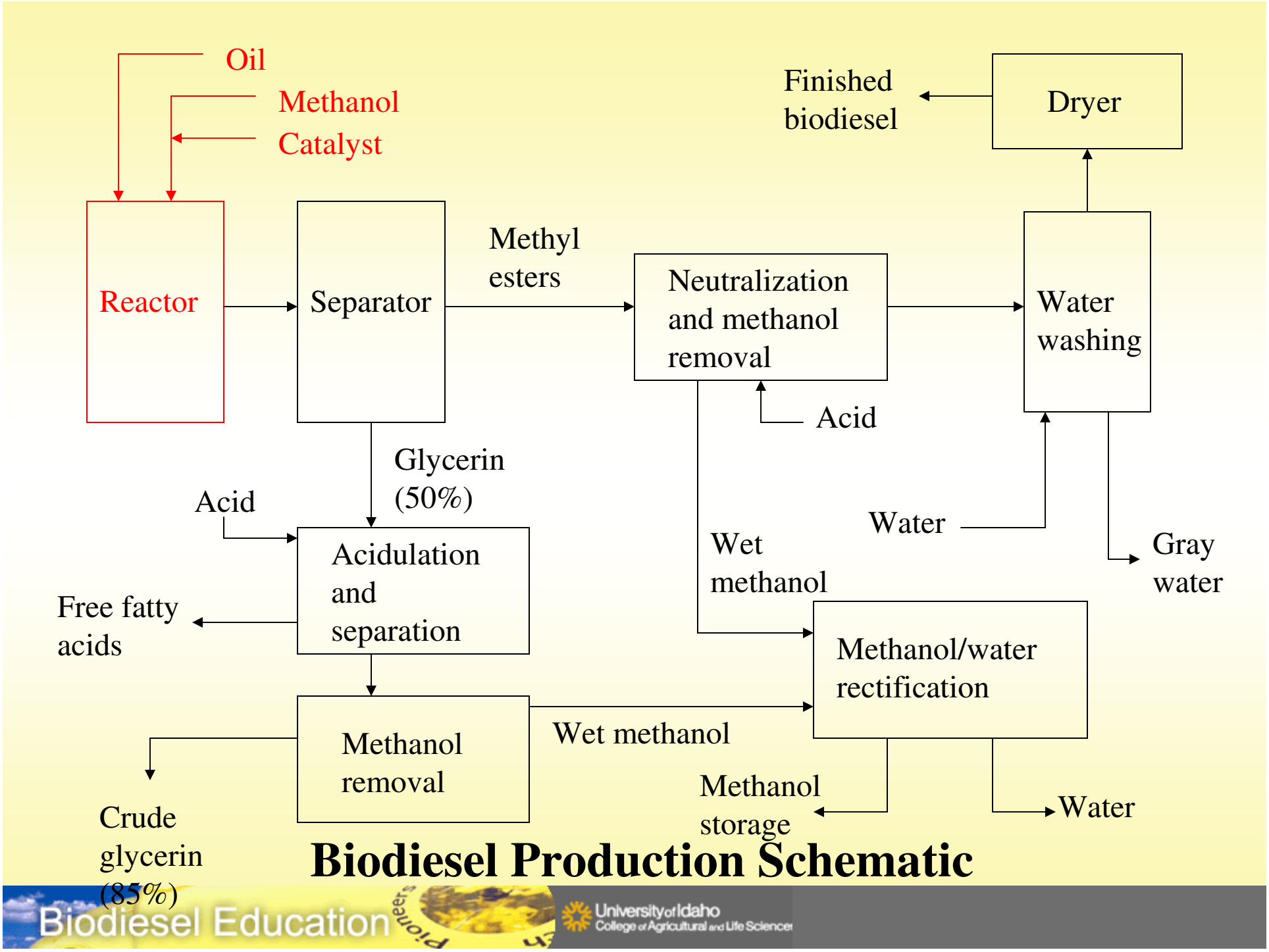
- Requires no engine modifications (except replacing some fuel lines on older engines).
- Can be blended in any proportion with petroleum diesel fuel.
- High cetane number and excellent lubricity.
- Very high flashpoint (>300°F)
- Can be made from recycled restaurant oils and animal fats.

Disadvantages of biodiesel

- **Lower energy content**

	Btu/lb	Btu/gal
No. 2 Diesel	18,300	129,050
Biodiesel	16,000	118,170
	(12.5% less)	(8% less)

- **Since diesel engines will inject equal volumes of fuel, fuel economy will drop 8%. (Power loss = 5-7%)**
- **Soybean oil-based biodiesel will start to crystallize at around 0°C. (Canola about -2 to -3 °C) This can be mitigated by blending with diesel fuel or with additives.**
- **Biodiesel is less oxidatively stable than petroleum diesel fuel. Old fuel can become acidic and form sediments and varnish. Additives can prevent this.**



Biodiesel Production Schematic

Feedstocks

- Any triglyceride-based oil can be converted to biodiesel.
- Feedstocks are typically divided into:
  - Vegetable-based
  - Animal-fat based
  - Recovered products (waste restaurant oils, trap grease, float grease, etc.)

Catalyst Options

- **Base Catalysts: NaOH, KOH, $NaOCH_3$**
  - **Sodium methoxide as a 25% or 30% concentrate in methanol is the preferred catalyst.**
- **Acid Catalysts: H_2SO_4, H_3PO_4, HCl**
  - **Acid catalysts can be used for transesterification but are slow. They are usually used for conversion of free fatty acids to esters.**
- **Non-catalyst options: supercritical reaction, lipase enzymes**

Canola

Soybeans

Camelina

- Promoted as an oilseed that will give canola-like yields, even on arid land.
- Presents the potential for growing crops on acres that are not currently used for food production (rangeland).
- Experience has shown that if you want decent yield, you still need rain.

Palm: Concerns about rain forest depletion, food competition.

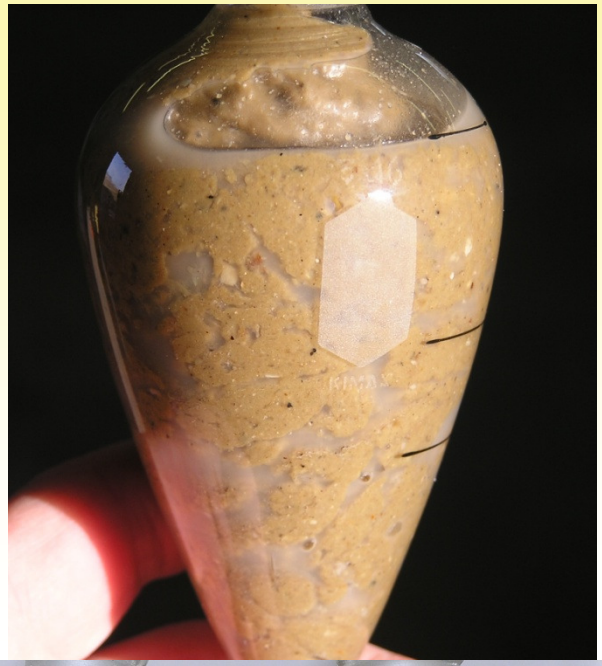
Nils Rettenmaier - IFEU

Biodiesel Education

University of Idaho
College of Agricultural and

Jatropha: High oil yield, grows on arid land, doesn't compete with food.

Trap Grease



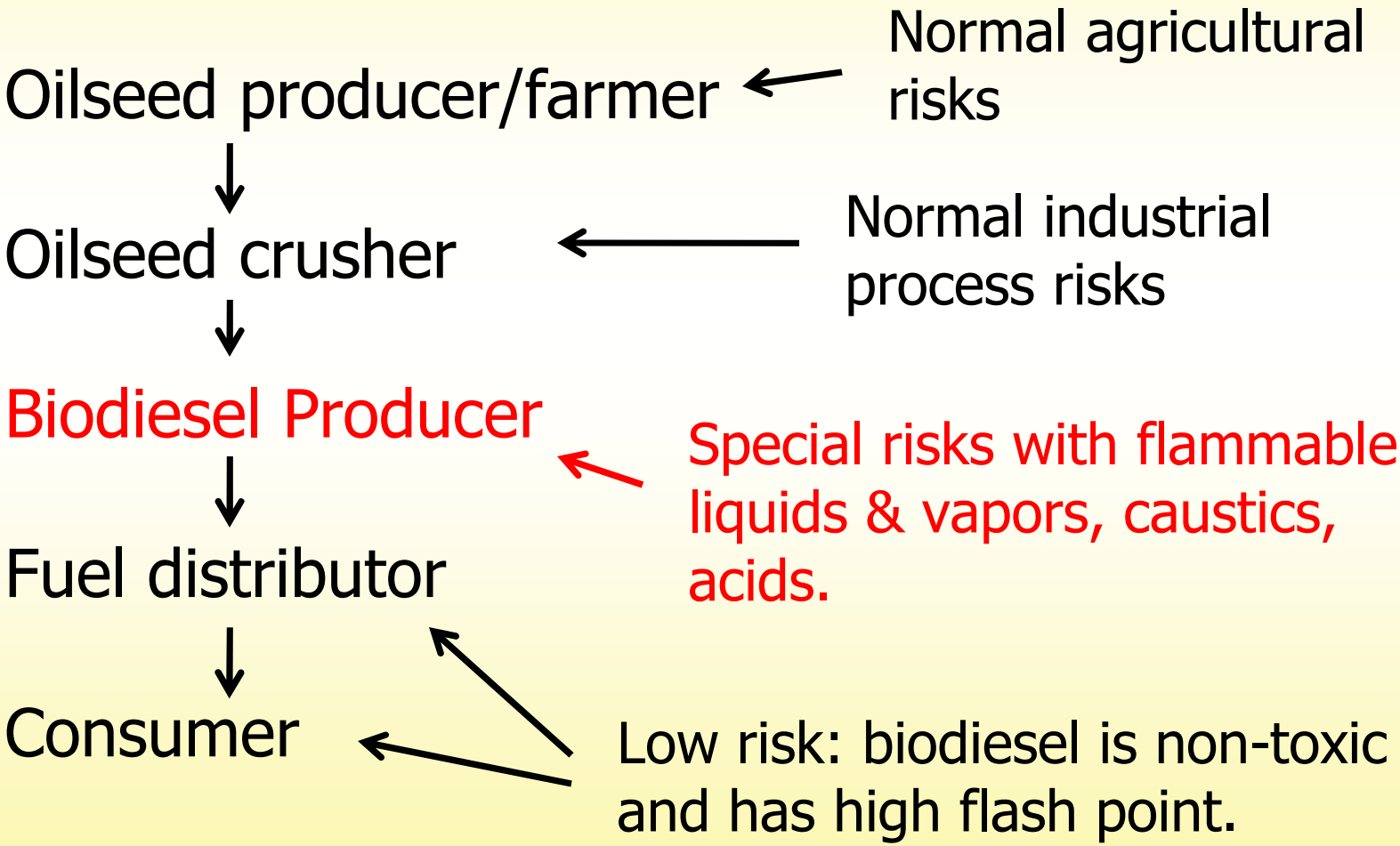
Algae

- Still major technical issues with large scale cultivation. Probably at least 10 years out.
- Most algae are photosynthetic. They convert energy from the sun into biomass (and oil).
- High cost of production is major issue.
  - High water consumption and invasive species require closed environment (bioreactor).
  - Closed environments are much more expensive than open ponds.
  - Solar-based systems are basically 2-D. They depend on surface area exposed to the sun. They require lots of land.
- Other problems include:
  - Need for nitrogen stress cycle.
  - Oil extraction is difficult.

Issues

- Direct land use changes
  - Converting rangeland to camelina or desert to algae ponds changes those eco-systems.
- Indirect land use changes
  - Converting forest or grassland to cropland in response to higher crop prices.
- All new feedstocks are going to have consequences.
  - Land use change.
  - Food prices.
  - Fuel quality

Biodiesel safety issues depend on where you are in the supply chain.



Safety Issues for biodiesel production

- Catalysts are strong bases.
- Acids are used for neutralization of catalyst and splitting soap.
- But, methanol is BY FAR the greatest concern….

1 Dead After Bio-Diesel Plant Explosion

Reporting

PRINCESS ANNE, Md. (WJZ) —
Maryland's attempt to produce greener energy took a dangerous turn after a bio-diesel plant exploded, killing one man and injuring another.

5/18/09

Explosion and fire destroys Idaho biodiesel plant, one dead

Idaho Statesman
Edition Date: 07-07-2006

An explosion and fire today at Blue Sky Biodiesel in the Payette County town of New Plymouth likely led to the death of a worker and shut down Highway 30 through the city for over four hours, according to an Idaho State Police spokesman.

Biodiesel plant remains closed after explosion

By Sarah Smith

Web exclusive posted Jan. 21, 2008, at 11:20 a.m. CST

Three weeks after an Ohio biodiesel plant exploded, injuring four, the American Ag Fuels plant is still undergoing repairs.

The Jan. 3 explosion rocked the plant's Quonset-style loading and unloading facility, and damaged a non-load bearing wall of the adjacent processing building, said Defiance, Ohio, acting Fire Chief Pete Schlosser.

Methanol Safety Issues

- Methanol is found in many common consumer products (eg. windshield wiper fluid)
- Toxicity
  - Very toxic if swallowed
  - Can be inhaled or absorbed through skin.
- Flammable
  - Burns with clear flame
  - Easily ignited
  - Potentially explosive

Methanol toxicity

- 80-150 ml is lethal dose
- 4 ml is enough to cause blindness
- Methanol poisoning from improperly prepared moonshine was a frequent cause of blindness and death during prohibition.

Skin absorption of methanol

- **0.192 mg/cm^2-min skin absorption rate.**
  [Int.'l Archives Of Occupation and Environ. Health. 47(1), Oct. 1, 1980.]
- **300 cm^2 of exposed skin for 1 hour could provide a risk of blindness.**
- **Protective clothing is a must. (rubber gloves, boots, apron, face shield)**
- **Breathing vapors can also provide exposure. Effect is cumulative.**
  - **OSHA Permissible exposure limit = 200 ppm**

Fire and explosion risk

- Methanol flash point = 12° C (54° F)
- Methanol boiling pt = 65° C (149° F)
- Flammability range = 6% to 36%
- Vapors are slightly heavier than air.
- Flame is invisible until other materials start to burn.

Fire fighting

- **Use foam, dry chemical, or carbon dioxide. Water is usually not effective.**

Spill clean-up

- Ventilate and remove sources of ignition.
- Wear protective clothing.
- Contain and recover liquid with absorbents (vermiculite, dry sand, SOLUSORB, etc.)
- Don't allow methanol to enter sewer system.
- Methanol spills to soil or water are reportable events.

First Aid – Always get medical attention immediately.

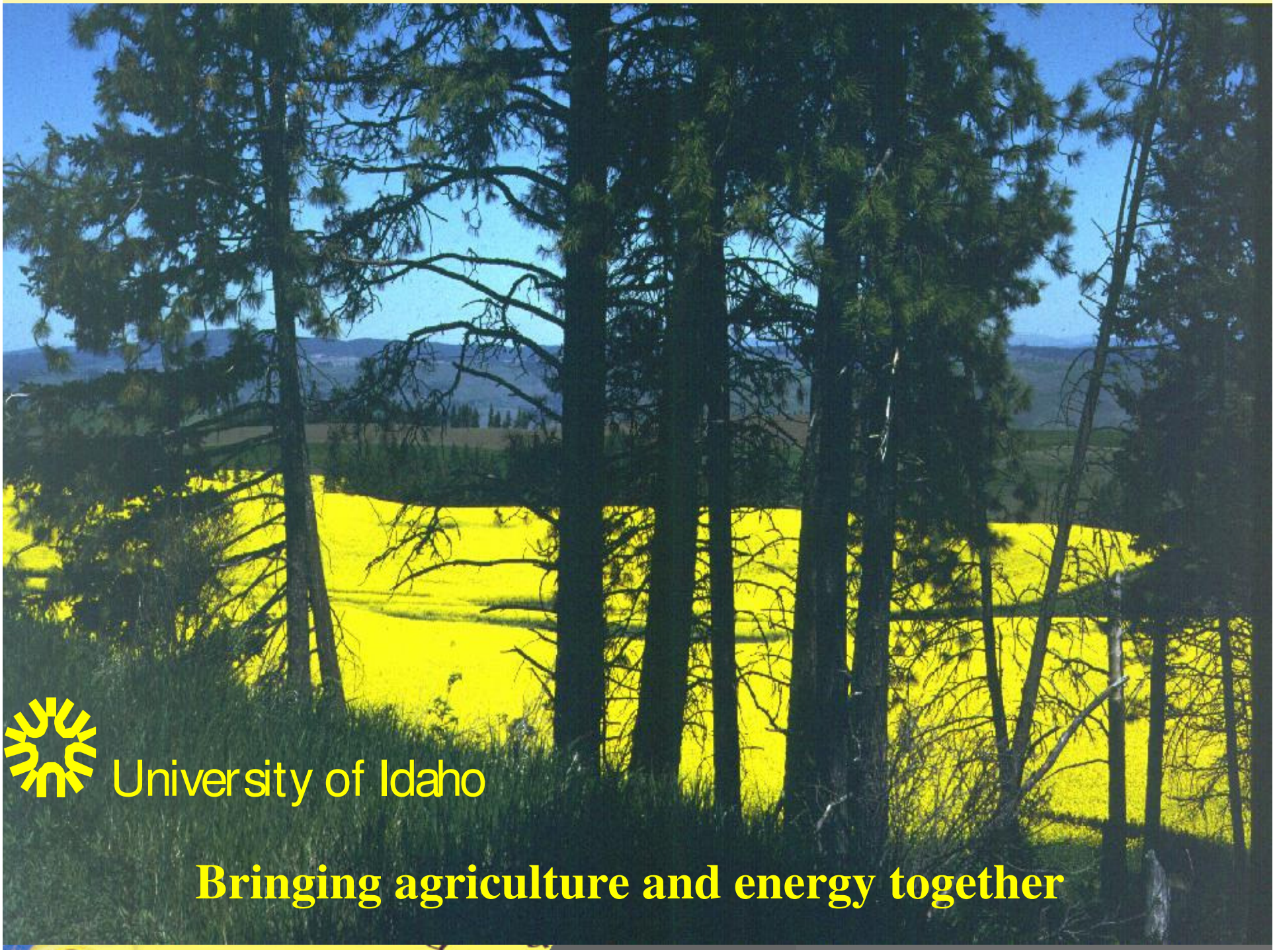
- Inhalation
  - Move to fresh air.
  - Use artificial respiration if not breathing. Provide oxygen.
- Ingestion
  - Follow instructions of medical personnel.
- Skin/eye contact
  - Flush immediately for 15 minutes. Clean clothing and shoes before reuse.

Work Practices

- All electrical equipment must be explosion-proof.
- All methanol-containing tanks should be enclosed and vented through a water scrubber.
- All tanks must be grounded. Avoid plastic tanks.
- No welding, cutting, or other hot work within a biodiesel production area or on tanks that have held methanol without proper precautions.

Further information

- www.BiodieselEducation.org
- www.me.iastate.edu/biodiesel
- www.biodiesel.org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